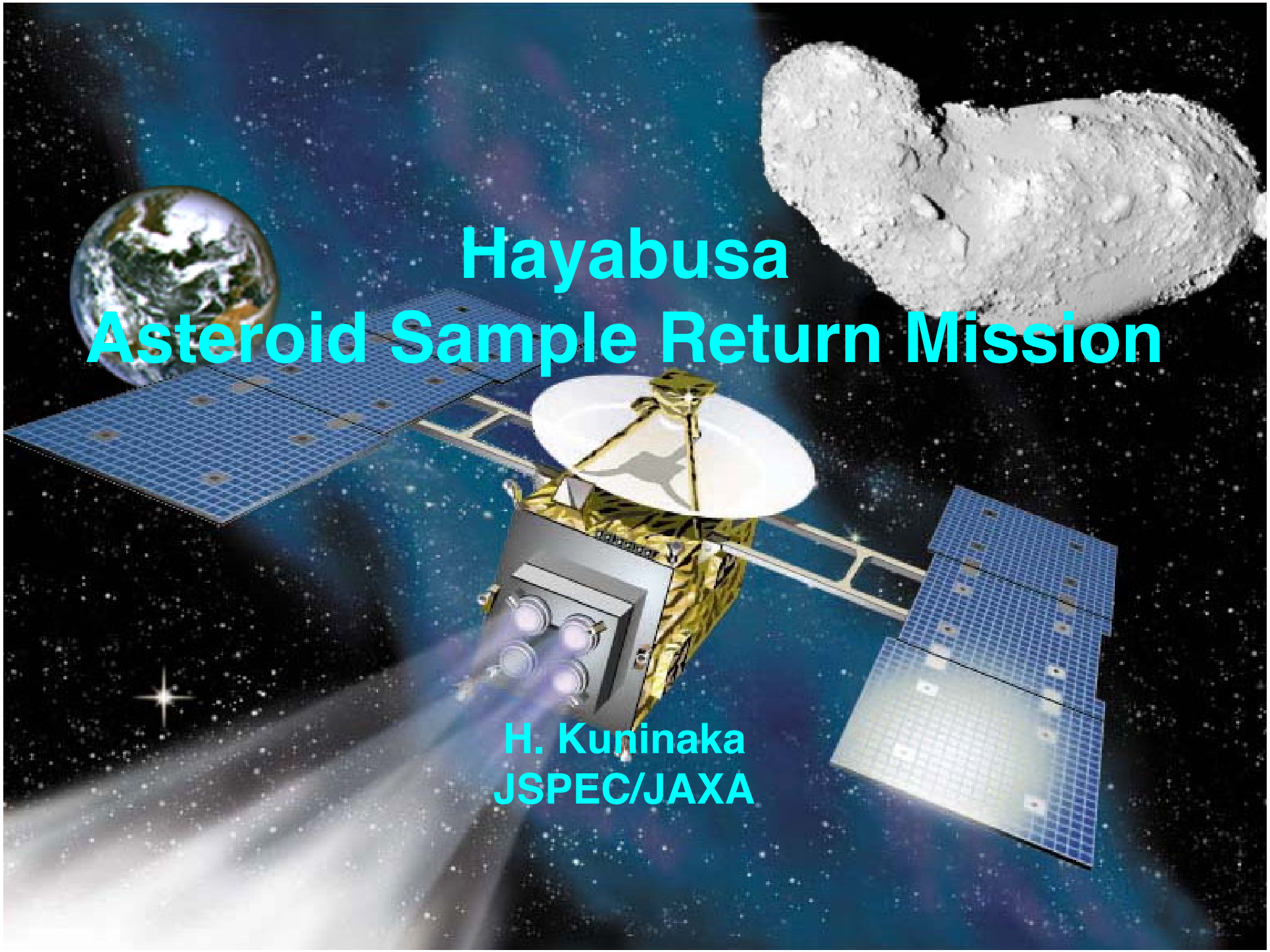
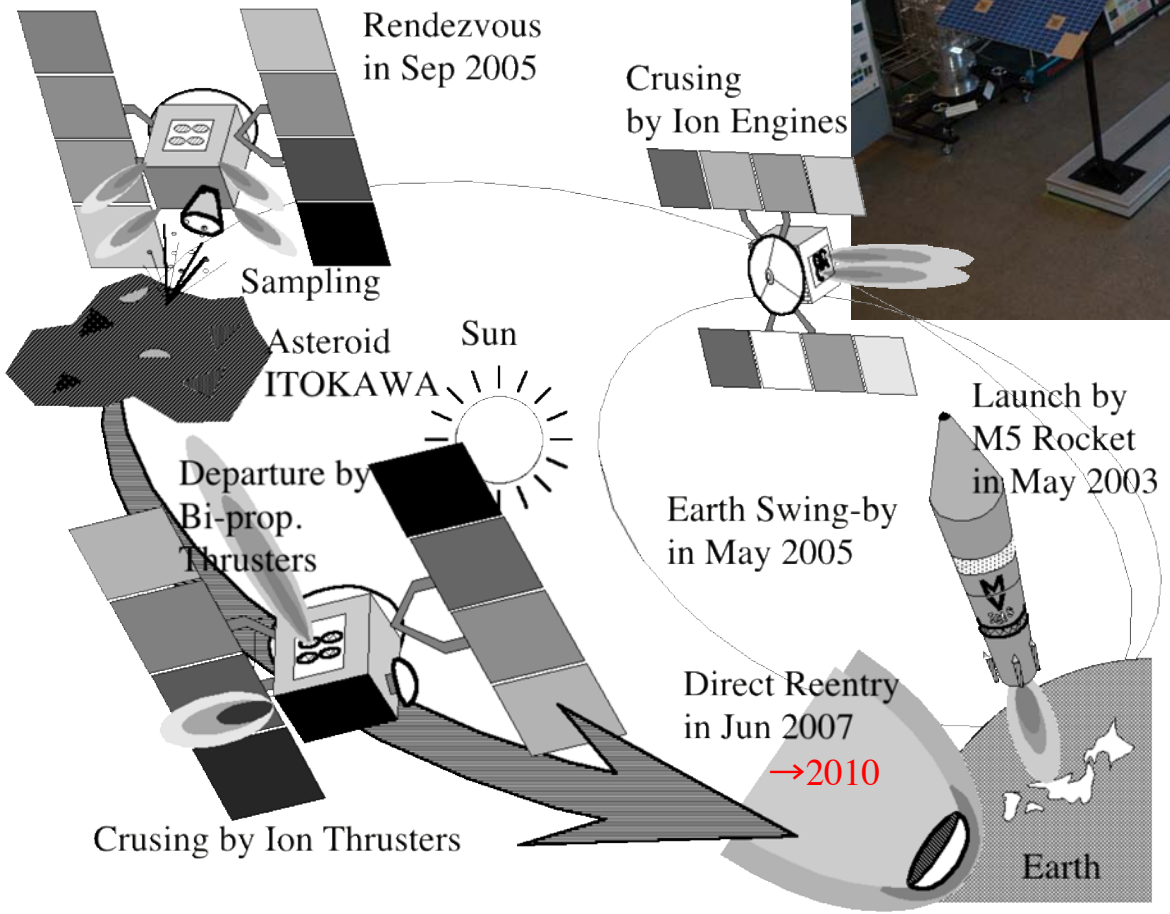

Hayabusa
Asteroid Sample Return Mission
H. Kuninaka
JSPEC/JAXA

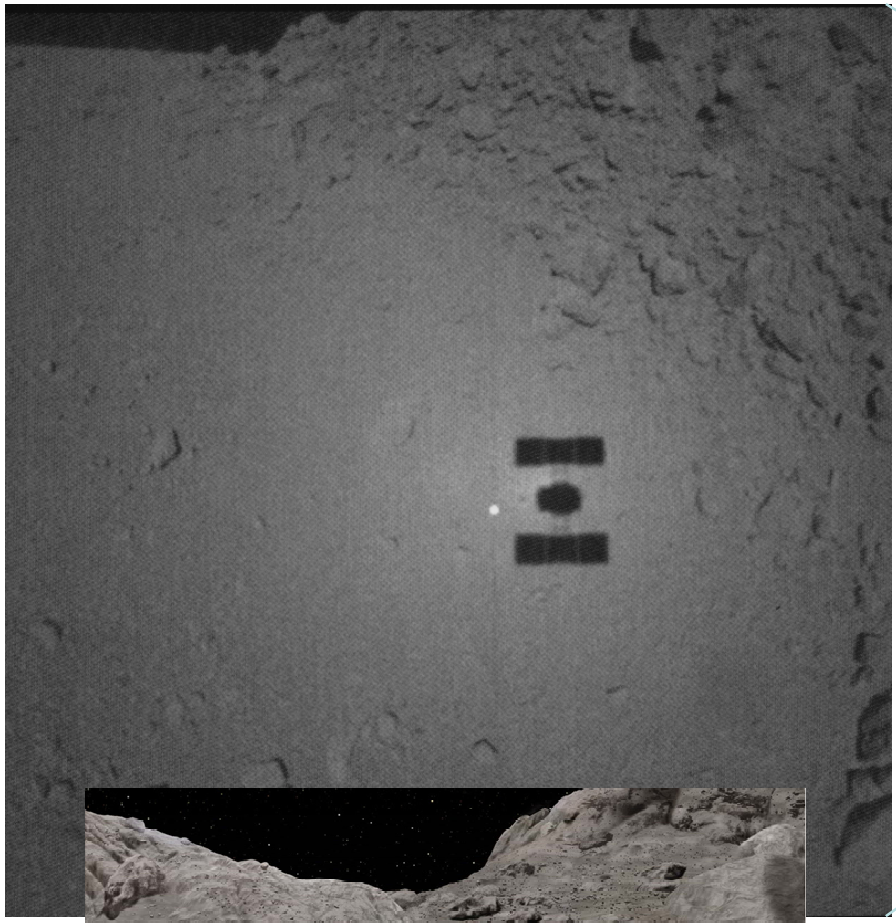
# Asteroid Explorer "Hayabusa"

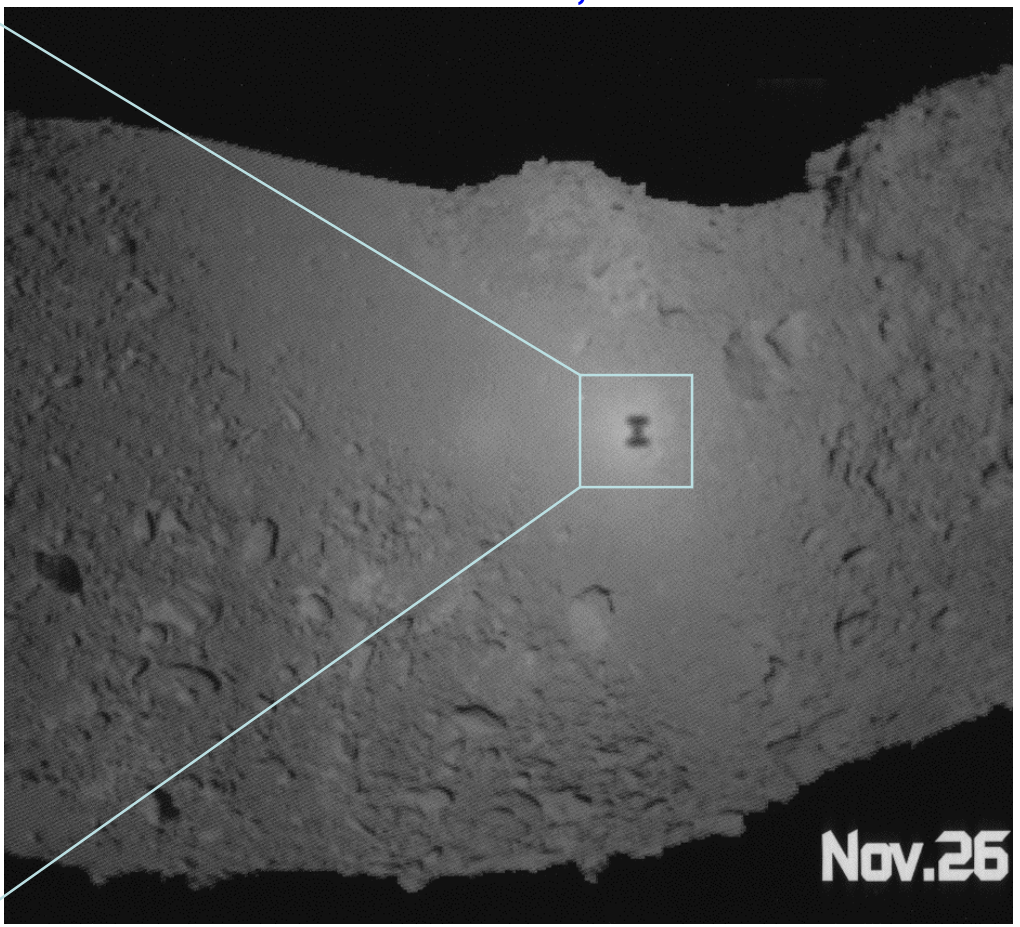


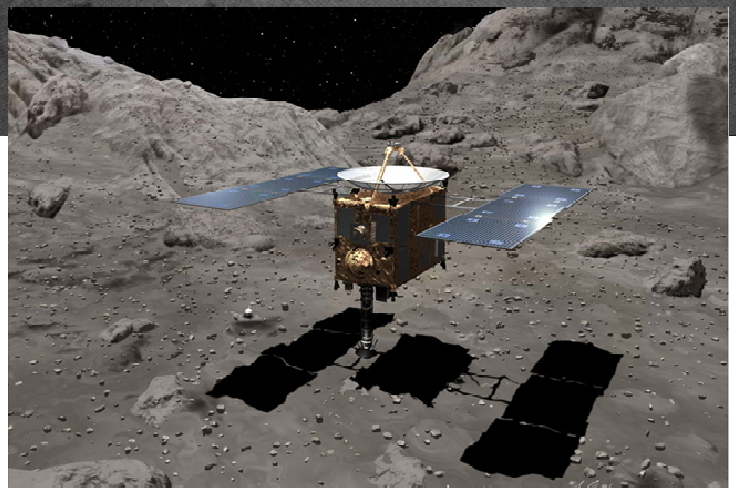

Dimensions
: 1.0m x 1.6m x 1.1m
Weight : 380kg(Dry)
Chemical Fuel 70kg
Xe Propellant 60kg
Total 510kg
Electric Power : 2.6kW@Earth
Communication : X band

# Closest Snapshot of Asteroid Itokawa

## Touch-Down and Lift-off on November 20, 2005



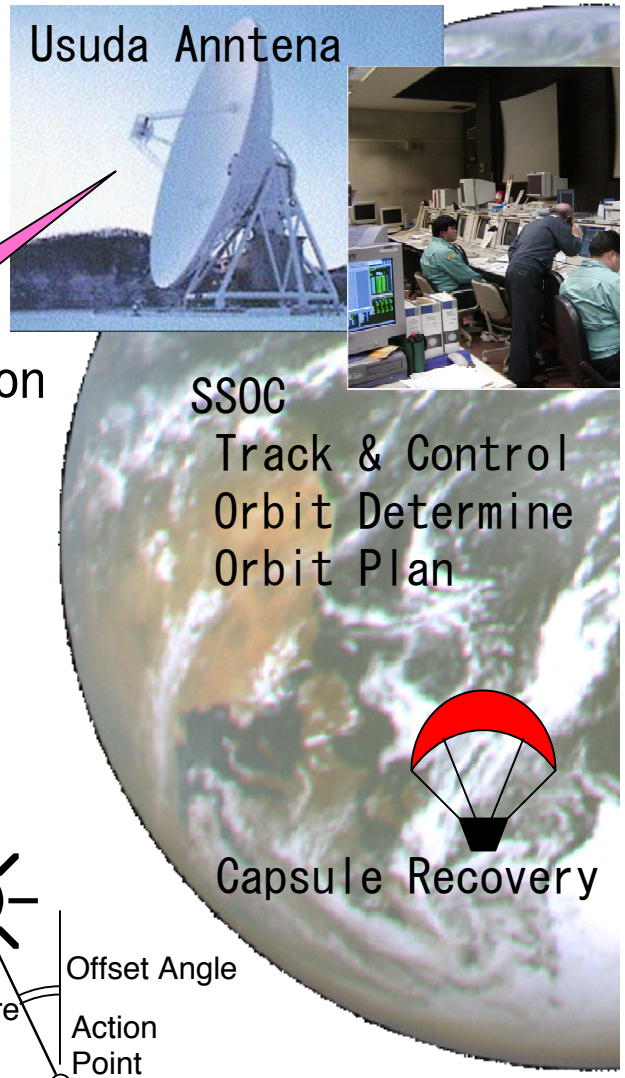


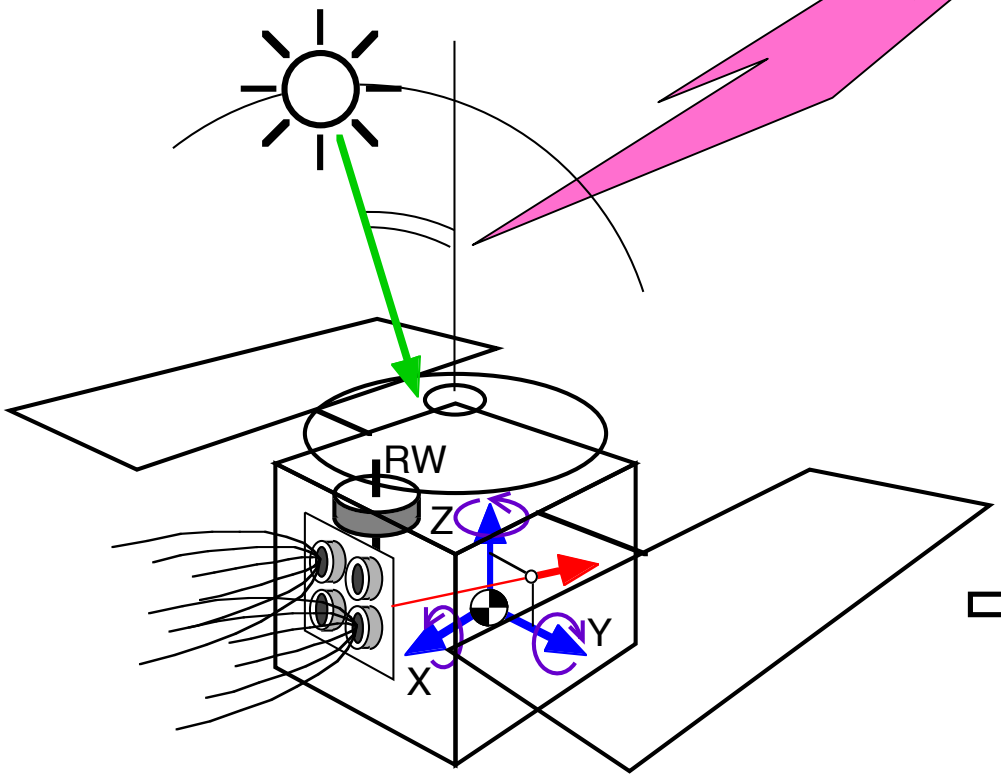



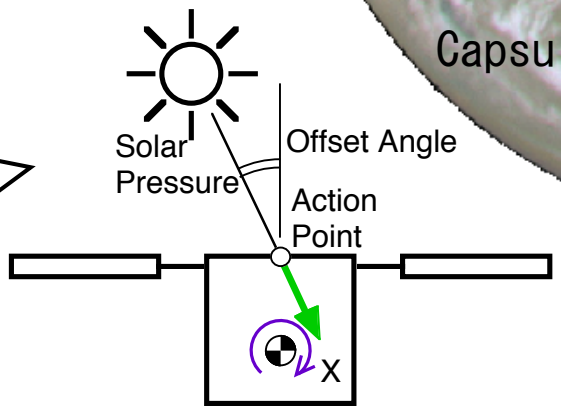
# Homeward Journey by Ion Engines from Apr 07

Malfunction Hydrazine Thrusters
Two of three Reaction Wheels

Space Operation
ΔV by Ion Engines
Thrust Vector Control for Y & Z-axis torques
Solar Pressure Torque around X-axis
Single Reaction Wheel for non-spin stabilization
Xenon Cold Gas Jets for Attitude Control



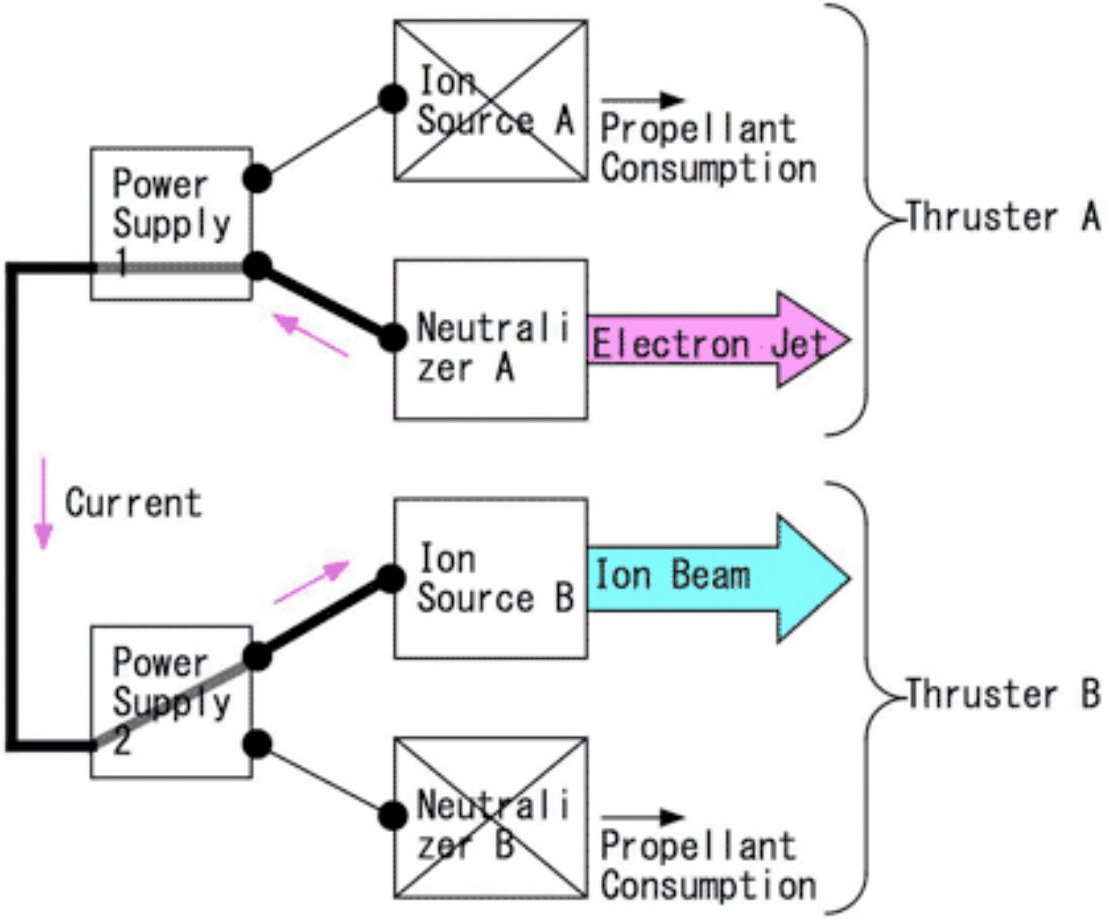



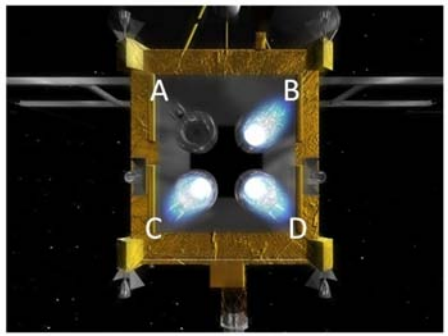
# Cross Connected Operation of Ion Engines

Thruster D was shut off on November 4, 2009.

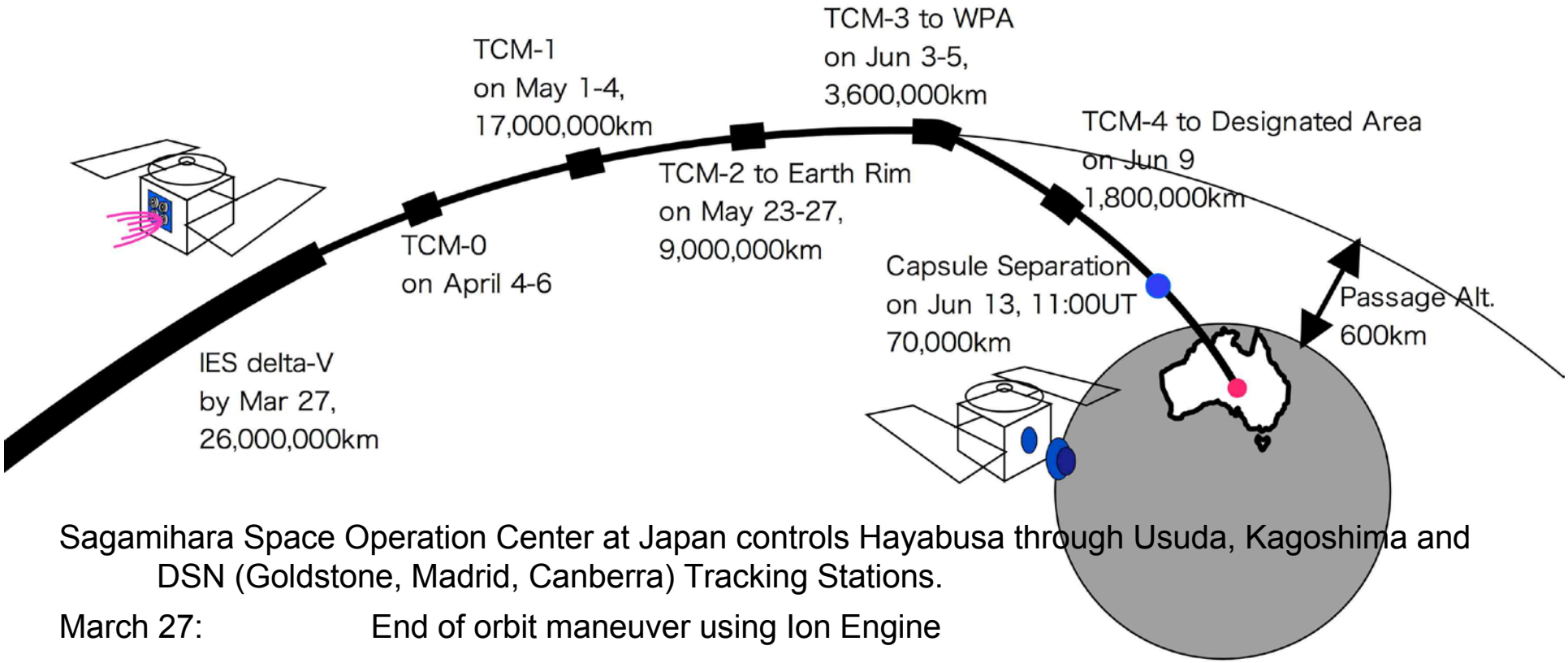
As counter measure Thruster-B combined with Neut-A generated enough thrust for the rest of the cruise.

The spacecraft was intentionally charged down to negative value, which made Neut-A emit electron current.



# Guidance Scheme to WPA

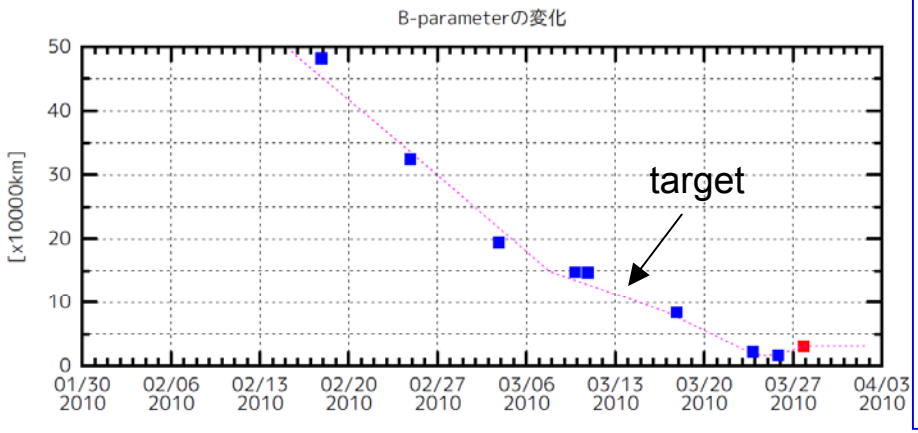



Sagamihara Space Operation Center at Japan controls Hayabusa through Usuda, Kagoshima and DSN (Goldstone, Madrid, Canberra) Tracking Stations.

| | |
|---|---|
| March 27: | End of orbit maneuver using Ion Engine |
| April 4-6: | TCM-0 |
| May 1-4: | TCM-1 guiding to Earth Rim |
| May 23-27: | TCM-2 precise guiding to Earth Rim above 600km altitude |
| June 3-5: | TCM-3 changing target from Earth Rim to WPA |
| June 9: | TCM-4 precise guiding to Designated Area in WPA |
| June 13 10:54UT: | Separation of Capsule from Hayabusa |
| June 13 13:51UT: | Reentry of Capsule into atmosphere and Extinction of Hayabusa |

(TCM = Trajectory Correction Maneuver)

# Hayabusa traversed over south pole and will fly-by at night side of Earth

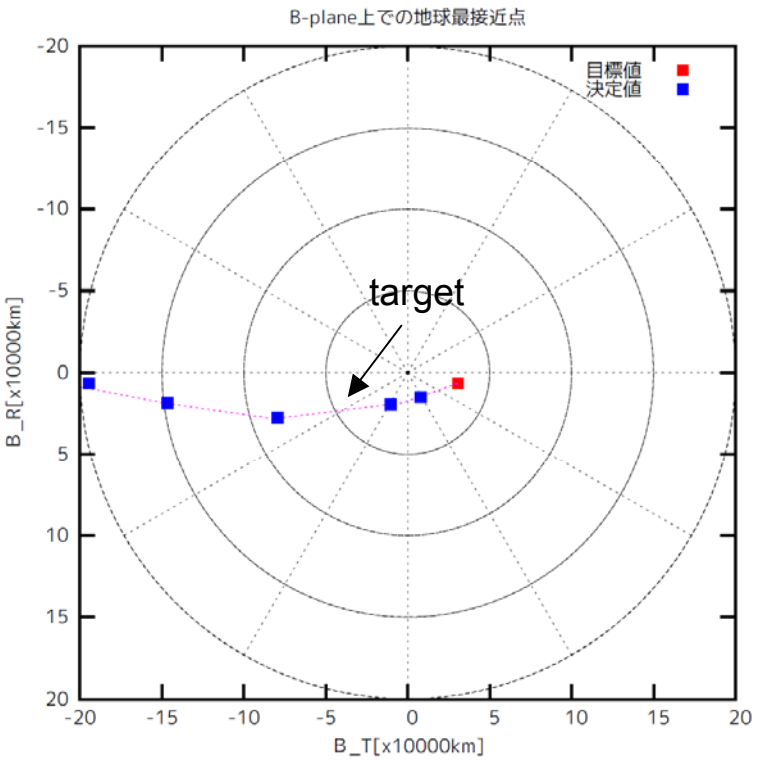


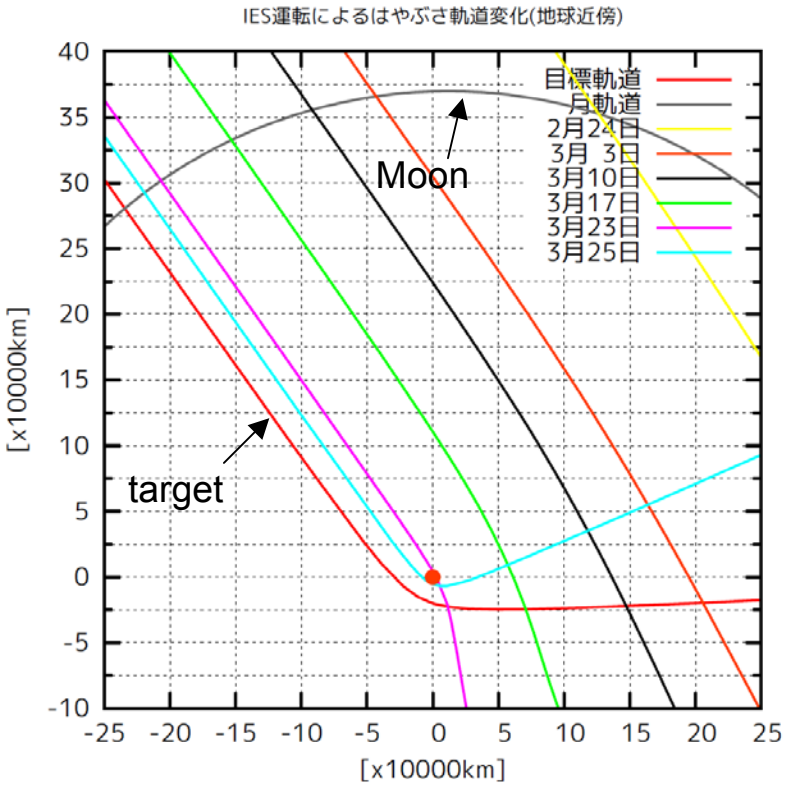

Left: Closest distance to Earth when Hayabusa flies ballistically from the moment designated.

Lower Left: The plane is normal to the approach velocity to Earth, and the horizontal axis corresponds to a crossing line with the equatorial plane. Sun is in the left hand side. Plots show the points where Hayabusa flies through this plane.

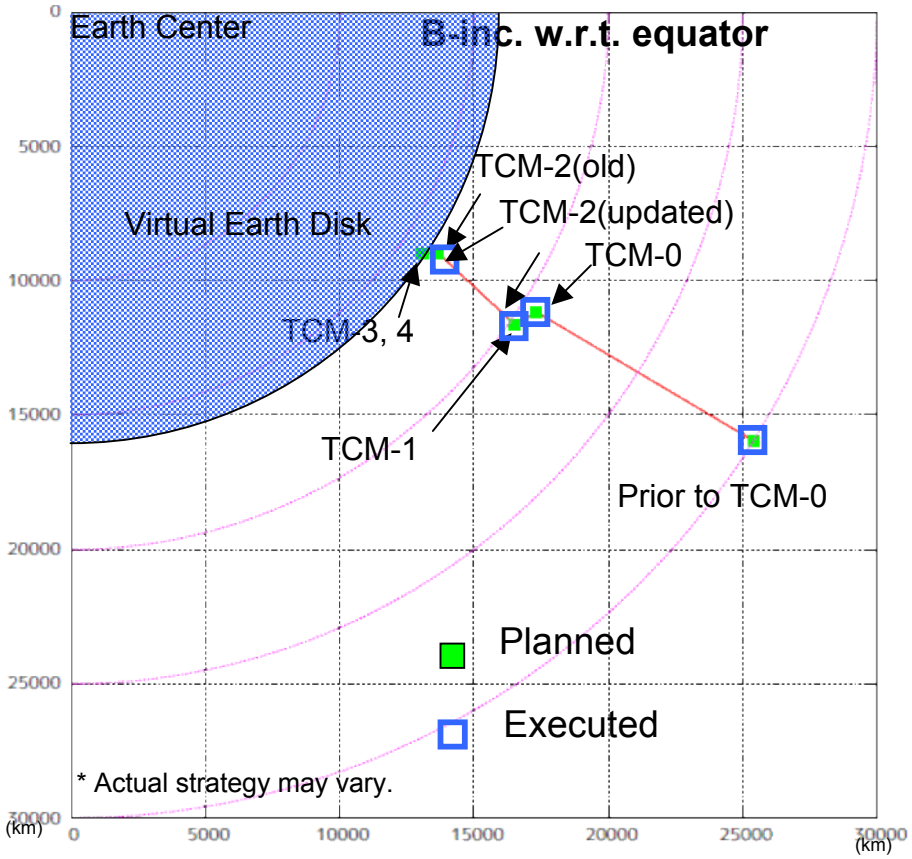
Bottom: Trajectories relative to Earth in inertial frame. The plane corresponds to the ecliptic plane.

Notes: Dates designated in the left figure do not indicate the return dates.



# Hayabusa completed the correction TCM-2

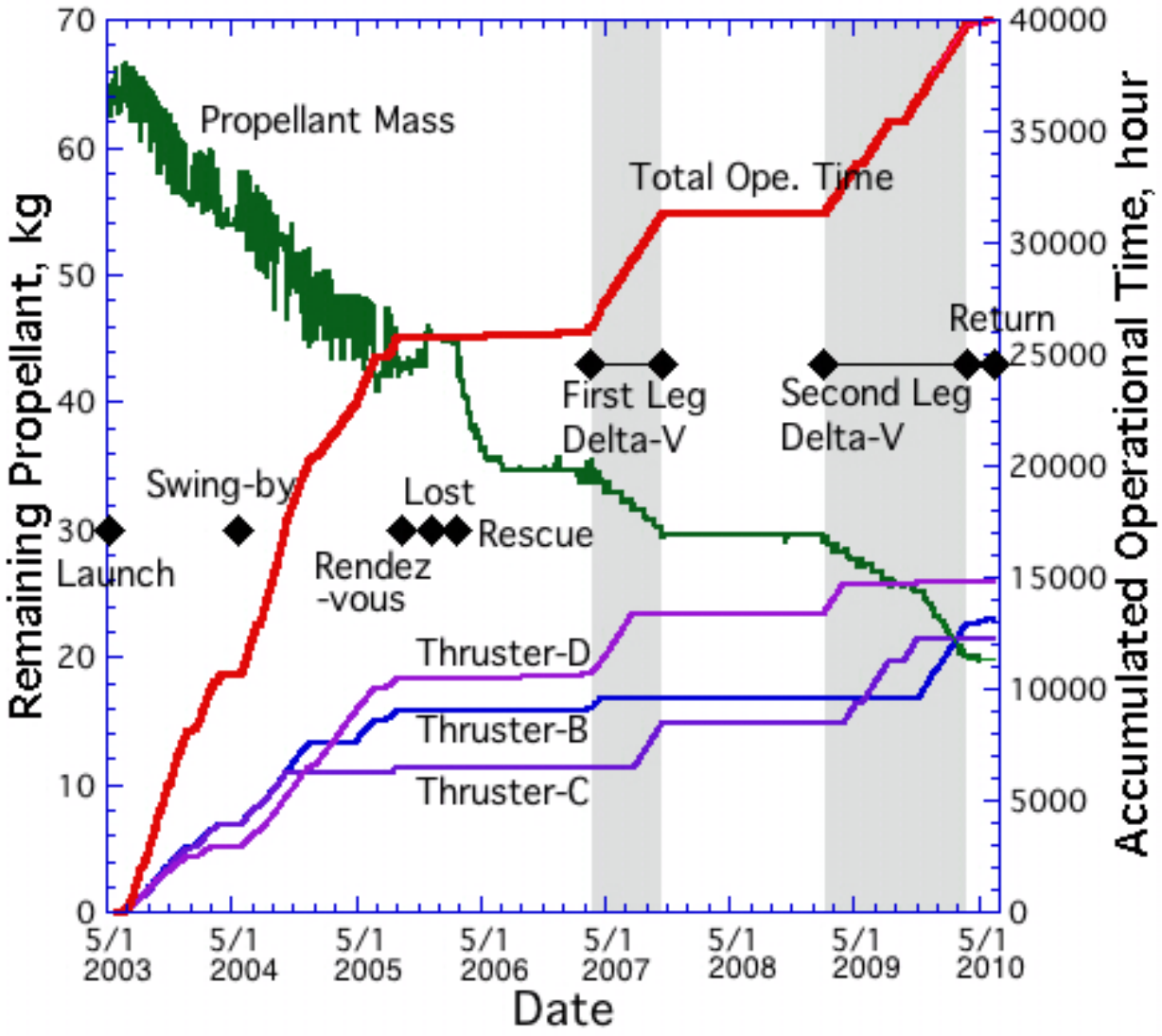



Left : The point where the spacecraft penetrates when no Earth gravity is assumed present. No entry before TCM-3. Virtual Earth Disk is 16 thousand km in radius.

Originally, TCM-2 aimed at the trajectory flying-by at the altitude of 200 km. However, in view of the attitude constraint, the project decided to raise the flying-by altitude to about 630 km. Increase in TCM velocity increment helps the attitude requirement relaxed. And TCM-2 was performed intending the attitude error resides in making the flying-by altitude relatively higher to further relieve the attitude constraint. Currently, the orbit determination is under way.

# Summary of Ion Engine Operation

Accumulated Ope. Time:
39,637 hour & unit
Powered Flight Time:
25,800 hour
Longest Operation of a Single Thuruster:
14,830 hour
Power Throttling:
250W-1,150W
Generated ΔV:
2,200 m/s

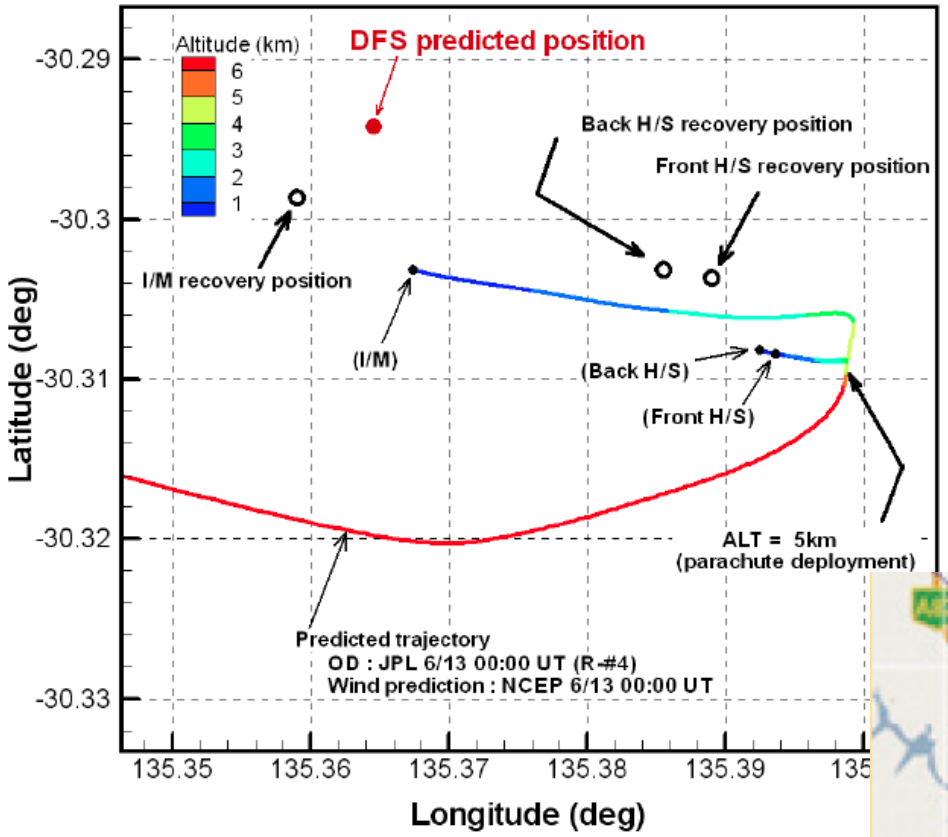


# Reentry and Recovery Operation at Woomera

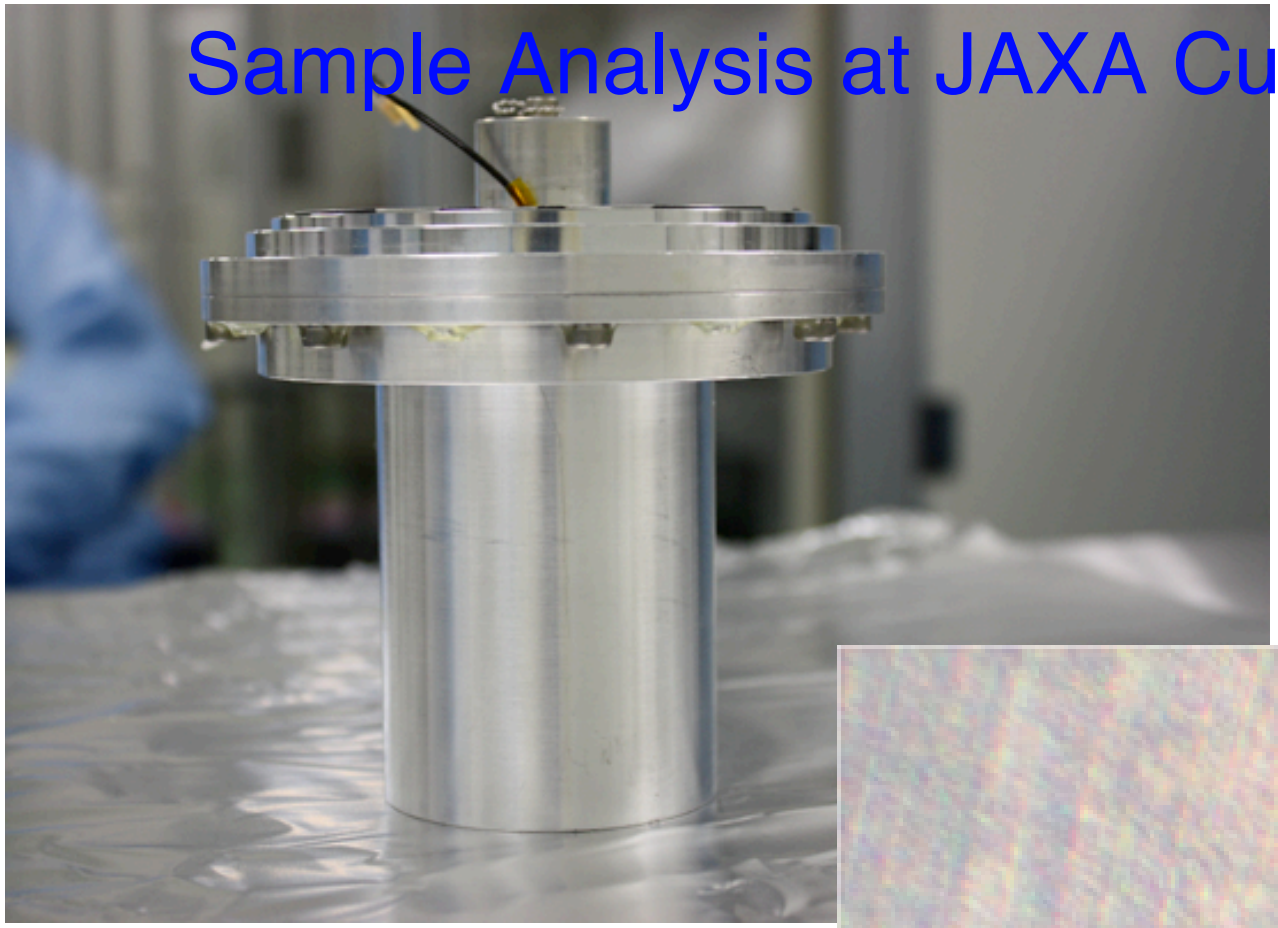
June 13, 14:00 UT

June 14

# Reentry and Recovery Operation at Woomera

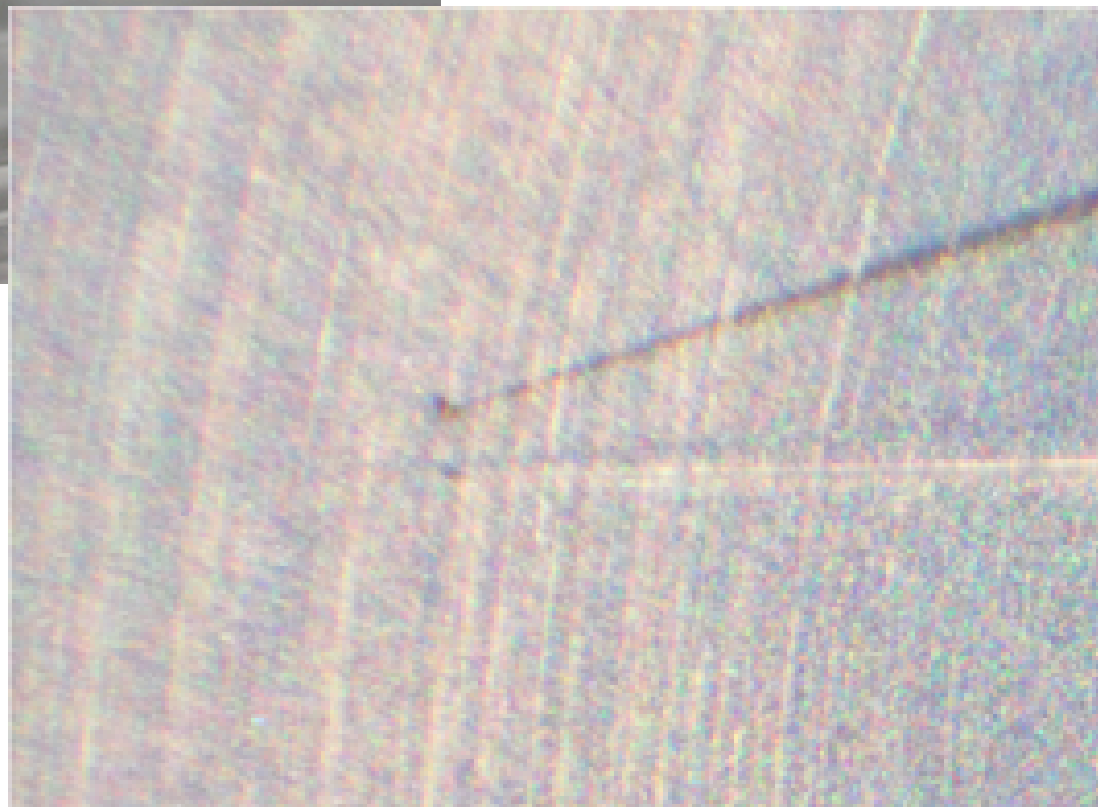



# Sample Analysis at JAXA Curation Center

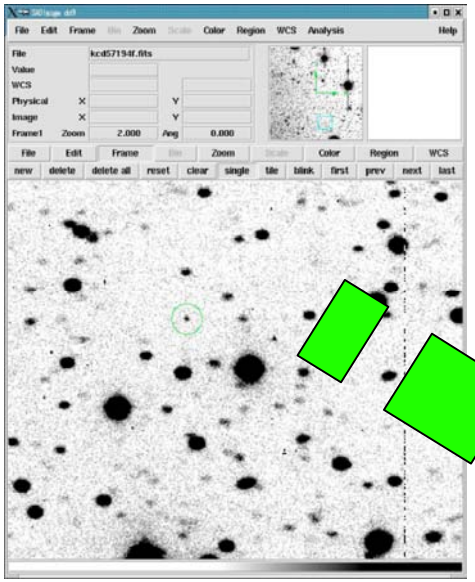


Sample Canister

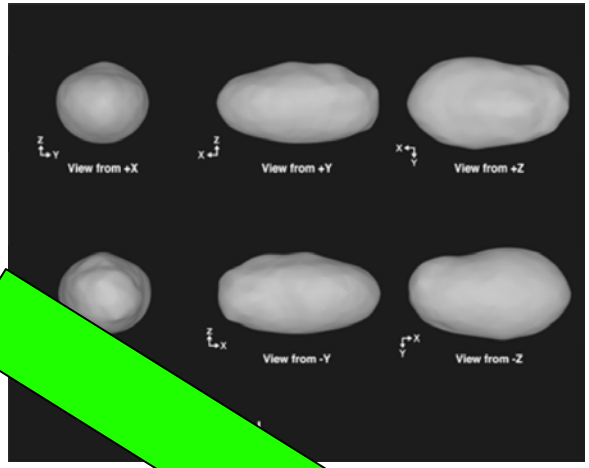
10μm particle
inside canister



# Resolusion

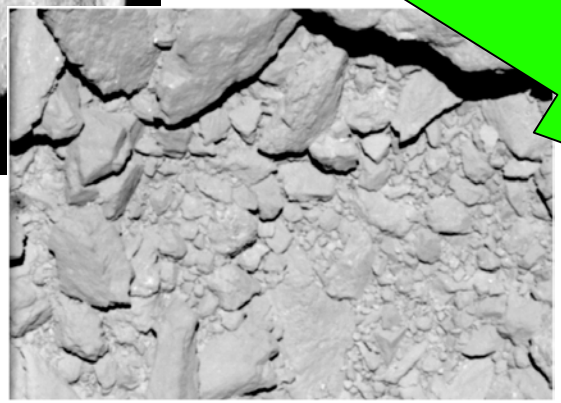


Telescope
AU



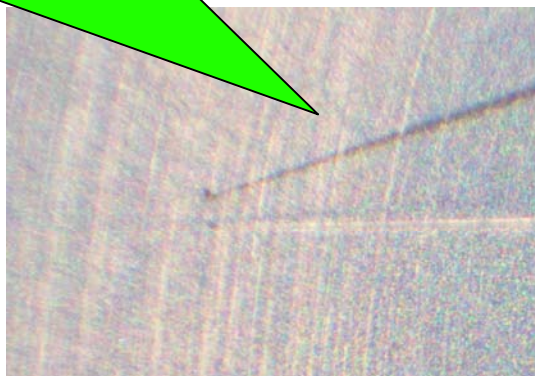

Rader
100m

Rendezvous
1m



Landing, 1mm

Return, 1μm



Hayabusa Space Mission was deeply helped by international space communities:

seamless tracking through NASA Deep Space Network
OD and EDL analysis by JPL/NASA
Reentry Airborne Observation by SETI
COLA analysis by STRATCOM
kind advice to ground recovery operation by ARES/NASA
landing authorisation by SLASO/Australia Government
Woomera operation by AOSG/DoD
liaison support by BAE Systems Australia
and so on.

On behalf of Hayabusa Project, I thank you from bottom of my heart for their collaborations.